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Large deformation analyses of space-frame structures, with members of arbitrary cross-section, using explicit tangent stiffness matrices, based on a von Kármán type nonlinear theory in rotated reference frames. (English) Zbl 1231.74038

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Summary: This paper presents a simple finite element method, based on simple mechanics and physical clarity, for geometrically nonlinear large rotation analyses of space frames consisting of members of arbitrary cross-section. A co-rotational reference frame, involving the axes of each finitely rotated beam finite-element, is used as the Updated Lagrangian reference frame for the respective element. A von Karman type nonlinear theory of deformation is employed in the co-rotational reference frame of each beam element, to account for bending, stretching, and torsion of each element. An assumed displacement approach is used to derive an explicit expression for the (12×12) symmetric tangent stiffness matrix of the beam element in the co-rotational reference frame. From the finite-displacement vector at each of the two nodes of the beam element, an explicit expression is derived for the matrix of finite rotation of the co-rotational reference frame from the globally-fixed Cartesian reference frame. Thus, this paper provides a text-book example of an explicit expression for the (12×12) symmetric tangent stiffness matrixof a finitely deforming beam element, which can be employed in very simple analyses of large deformations of space-frames.

MSC:

74B20 Nonlinear elasticity
74K10 Rods (beams, columns, shafts, arches, rings, etc.)

Keywords:

large deformation; unsymmetrical cross-section; explicit tangent stiffness; updated Lagrangian formulation; co-rotational reference frame; rod; space frames

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